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Concrete Construction

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A Preliminary Pamphlet

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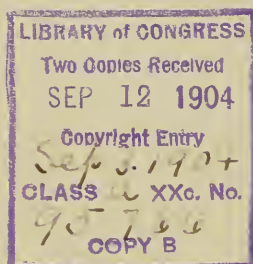
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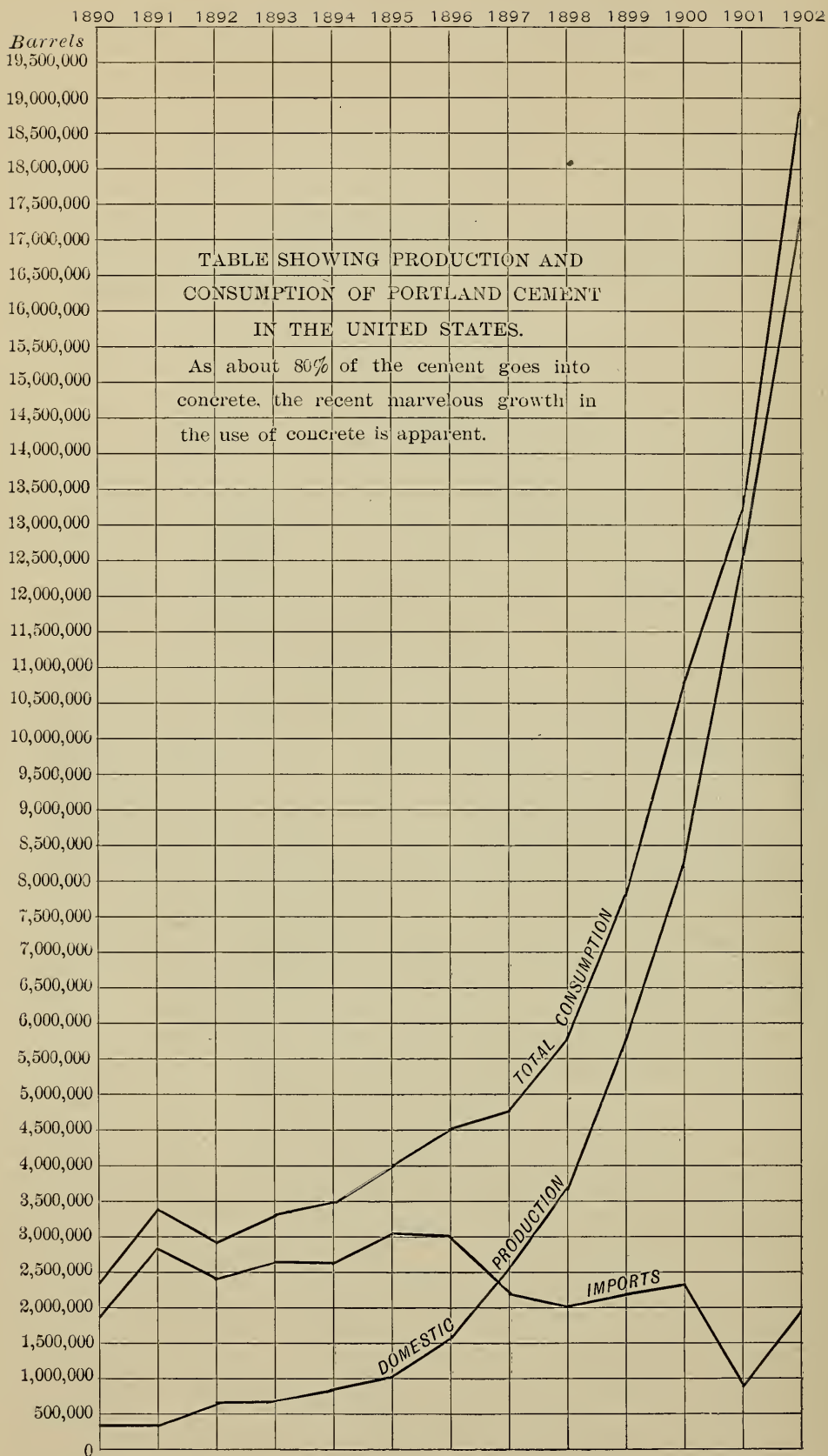
Concrete Construction

“It seems almost a philosophical thought that, in this age, when man changes and thought changes so quickly, the material representing the period is of a plastic and flexible nature.”—ROBERT W. LESLEY, in *June Cement Age*.

THERE is no other single subject which is at this moment engrossing so much of the attention of the engineering world as that of concrete construction. Within the last few years the use of concrete as a material of engineering has received an enormous impetus. New uses are constantly being found for concrete and it is ever encroaching upon the fields hitherto occupied by stone, steel, hollow tile, etc. In other words, we are entering upon an “Age of Concrete.” Therefore this brief treatise about concrete, its properties and applications, may be considered timely.

What concrete is

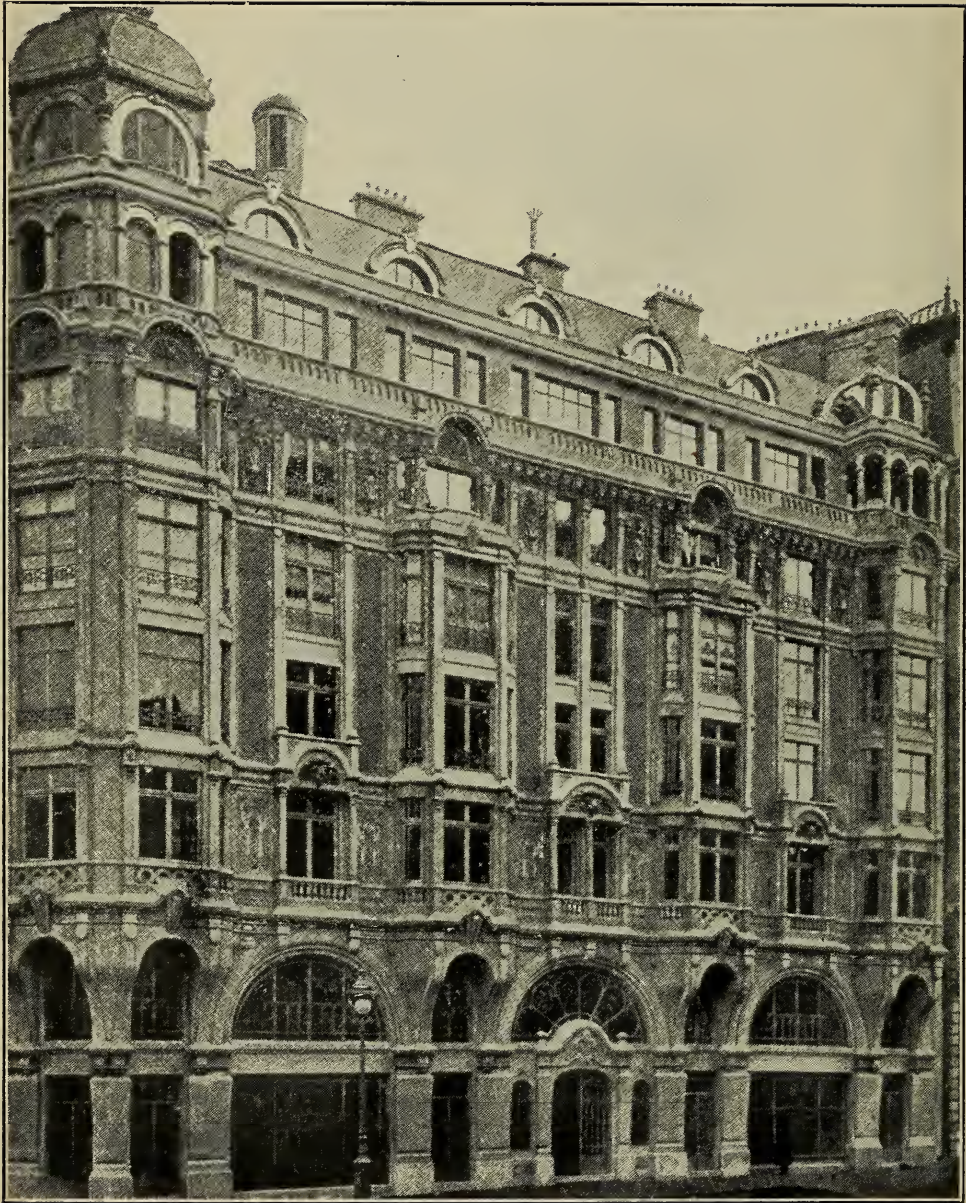
Concrete may be defined as an artificial stone. It can be used for all structural purposes as a substitute for stone and in addition it has a wide variety of applications where the use of stone is impracticable. Concrete is composed of broken stone or



gravel, sand and cement with the addition of water sufficient, after allowing for evaporation and absorption, to unite chemically with the cement.

A typical concrete is made as follows: To one barrel of a standard Portland cement are added three barrels of clean sharp sand. The two are intimately mixed—either manually or by a mechanical mixer—and then enough water is added to bring the mixture to a certain consistency, the proper amount of water being readily judged by one experienced in this work. Five barrels of broken stone are then added, the whole thoroughly intermixed, and the concrete thus formed is ready to be conveyed to the forms or the excavations prepared for it. Concrete made in the above proportions would be known as a 1:3:5 mixture. The permissible proportions, however, vary widely from 1:2:4 to 1:5:10 according to the nature of the ingredients and the service for which it is intended. In general, concrete with the smaller proportion of cement will not sustain the same strains as the concretes wherein the proportions are about as indicated in our typical mixture.

The composition of a properly proportioned concrete may be thus considered; sand fills up the interstices between the pieces of rock, and the cement, in turn, fills up the interstices between the particles of sand and between the sand and the rock. As 90% of a standard cement will pass through a sieve of 10,000 meshes to the square inch, it is evident that the cement will effectually fill up all voids. But the cement also performs an even more important function. It enters into chemical combination with the water used in mixing and acts as a binder, tenaciously holding the whole mass together. As soon as the cement is mixed with water this chemical change commences, or



**HENNEBIQUE'S APARTMENT HOUSE,
1 RUE DANTON, PARIS.**

The entire structure is of re-enforced concrete.

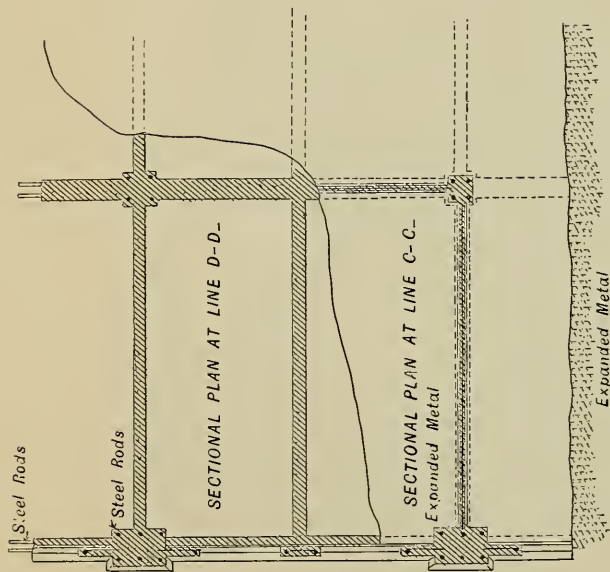
the concrete begins to "set" as it is generally expressed. Therefore the concrete must be put in place immediately after mixing. At the end of about three or four days, the concrete is solid enough for the supporting forms to be removed and, after possibly thirty days, it is ready for the loads for which it is designed. The hardening continues for months and the concrete becomes stronger as time elapses.

**Advantages resulting
from its plasticity**

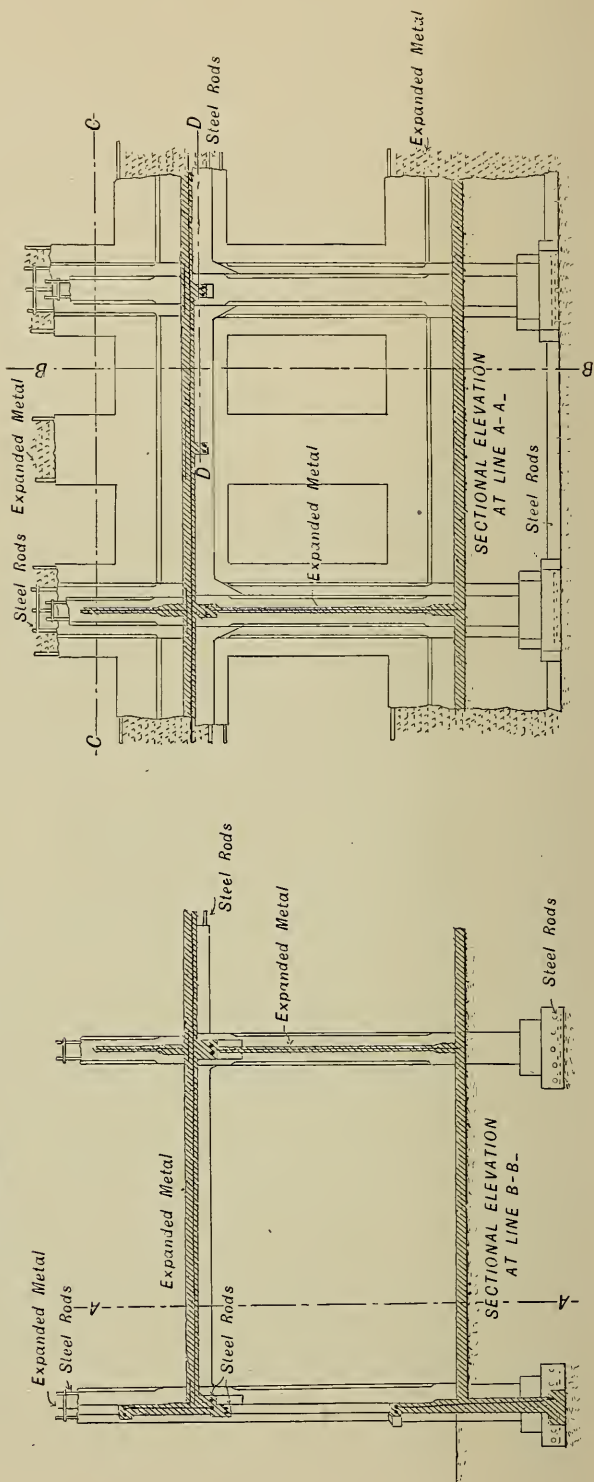
The fact that concrete can be moulded into any form desired is a most valuable quality and one which is largely availed of in practice. Aside from such uses as being simply deposited for foundations, abutments, etc., it is moulded into shapes as intricate as may be desired, one of the recent applications which is being extensively developed at the present time being the use of concrete for making hollow blocks for building purposes. The facility with which it can be moulded for producing decorative effects is, of course, well-known. Another highly important advantage resulting from the plasticity of the newly-mixed concrete is that other materials, such as iron, may be imbedded in it, this feature being hereafter treated at length.

**Concrete is not an
untried material**

The merits of concrete as a material of construction have been recognized for centuries. Some of the most enduring monuments of antiquity are constructed either wholly or in part of this material. The dome of the Pantheon, erected about the beginning of the Christian era, is built of concrete as are some of the other historic structures of that period. Concrete has ever since been used to a greater or less extent. With the discovery and applica-



REINFORCED CONCRETE BUILDING SECTIONS
 SHOWING COLUMN, PILASTER, FLOOR, BEAM, GIRDER,
 FOOTING, CURTAIN WALL AND PARTITION CONSTRUCTION.
Engineering Company of America, 74 Broadway, N. Y.



tion of the methods of making Portland cement, which we may ascribe to the period 1820-50, concrete assumed its place as one of the principal materials of engineering and we may say that each year has shown an increase in the amount of concrete construction with a constant widening of the field of its applications.

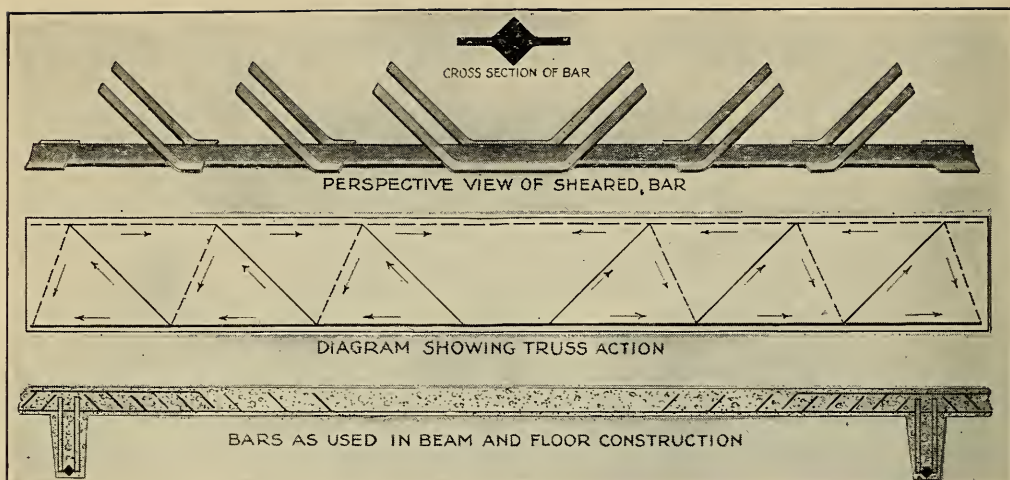
**Concrete re-enforced
with steel provides
for all strains**

The strength and durability of all concrete depend, of course, upon the quality of the ingredients and the care exercised in mixing and handling. When the work is done under experienced supervision, however, the characteristics of the resulting concrete can be accurately predicted. Concrete will withstand enormous compression strains. When heavy strains other than those of compression are to be provided for, the concrete is so strengthened with steel that the metal takes the tensile and shearing strains and the concrete, the compression strains. This construction, known as armored or re-enforced concrete, is rendered entirely feasible by the facts that concrete has considerable adhesion for iron and steel and the co-efficients of expansion (by heat) of the two materials are practically identical.

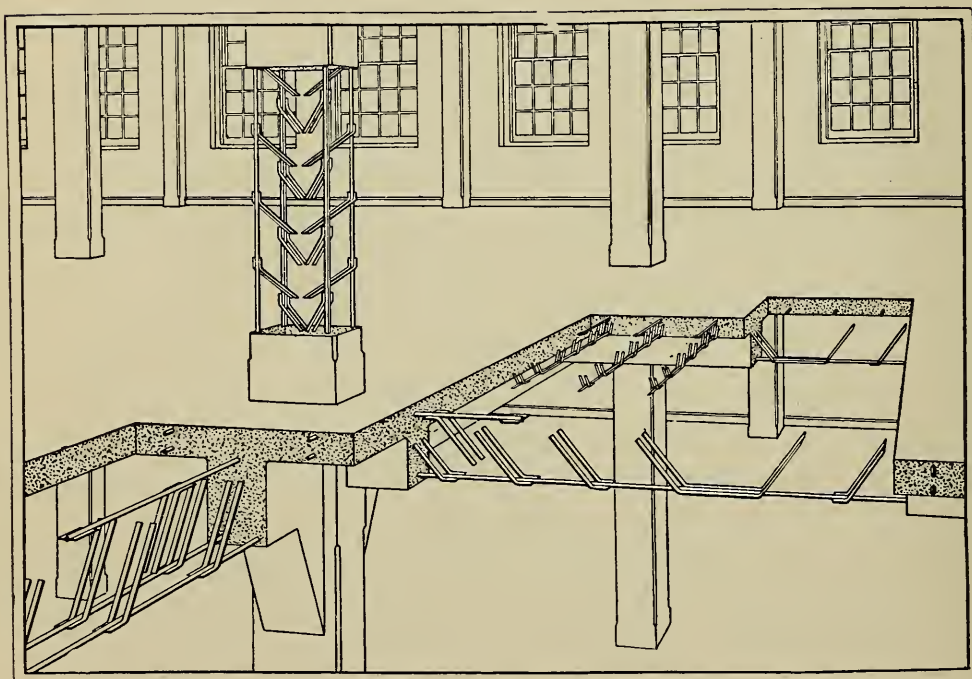
There are a number of "systems" of re-enforcing concrete with steel. We need not here discuss their relative merits as some have particular advantages for some purposes and others, for other purposes. Furthermore, the principles on which they are all based are identical.

**Some of the more im-
portant applications**

Although many of the applications of concrete are of recent date, the material has passed completely beyond the experimental stage. No case is known of the failure of a concrete structure *which has been erected under competent engineering*



THE TRUSSED STEEL BAR FOR CONCRETE RE-ENFORCEMENT.



ADAPTATION OF THE TRUSSED STEEL BAR.

supervision. Concrete, re-enforced with steel, has been successfully used in the following :

Office Buildings,	Bridges,
Apartment Houses,	Culverts,
Theatres,	Abutments,
Schools,	Sea-walls,
Court Houses,	Breakwaters,
Public Libraries,	Jetties,
Factories,	Piers,
Mills,	Reservoirs,
Warehouses,	Tanks,
Foundries,	Dams,
Grain Elevators,	Aqueducts,
Stables,	Sewers,
Cisterns,	Subways,
Bins,	Dust-chambers,
Stand-pipes,	Chimneys,

Besides a great number of minor uses in buildings constructed primarily of other material.

**The superiority of
concrete as a fire-
resisting material**

As regards the all-essential quality of ability to resist fire, concrete is absolutely and unqualifiedly superior to all other building materials. This has been shown many times in tests conducted by the building and fire departments of various large cities in this country and abroad. The usual way of conducting such tests is to build a small structure of concrete and to maintain therein a fire of a temperature of about 1,700° F. for a number of hours. A stream of water is then turned on the fire and concrete, and results are carefully noted. In general, a few hair-like

Excerpts from an editorial in

The New York Times.

NEW YORK, MONDAY, JUNE 6, 1904.

A CEMENT BUILDING

The building in Cincinnati of the first concrete office building of the modern "skyscraper" type is an event of more than ordinary architectural and technical interest. It points to the almost unlimited possibilities of this material in building construction, without fully realizing those which will be found of the greatest interest and value * * * * *

From a description published in The Architectural Record we take the following summary of its distinctive features:

The Ingalls Building occupies the entire area of a corner lot, 50 by 100 feet, and is fifteen stories, and a full attic, practically sixteen stories, rising to a height of 210 feet above the sidewalks. The one-half of the basement is the usual twelve feet deep; but the other half, containing the power plant, is twenty feet deep. The foundations extend five feet below this, so that the entire height of the structure from the bottom of the foundation is 235 feet, entirely concrete-steel. In fact, it is a concrete box of eight-inch walls, with concrete floors and roof, concrete beams, concrete columns, concrete stairs; the whole entirely devoid of the usual I-beams, Z-bars, angle irons, plates, rivets, and bolts. * * * * *

The Baltimore fire emphasizes with great clearness the value of steel reinforced concrete as a fire-resisting material. The future of plastic architecture is full of promise, and when it is remembered that the annual per capita consumption of cement in this country had reached in 1902 the astonishing figure of 119 pounds, in the aggregate some 30,000,000 barrels, it is not unsafe prophecy to predict for it a steady encroachment upon the field of every form of building material now available, wood included.

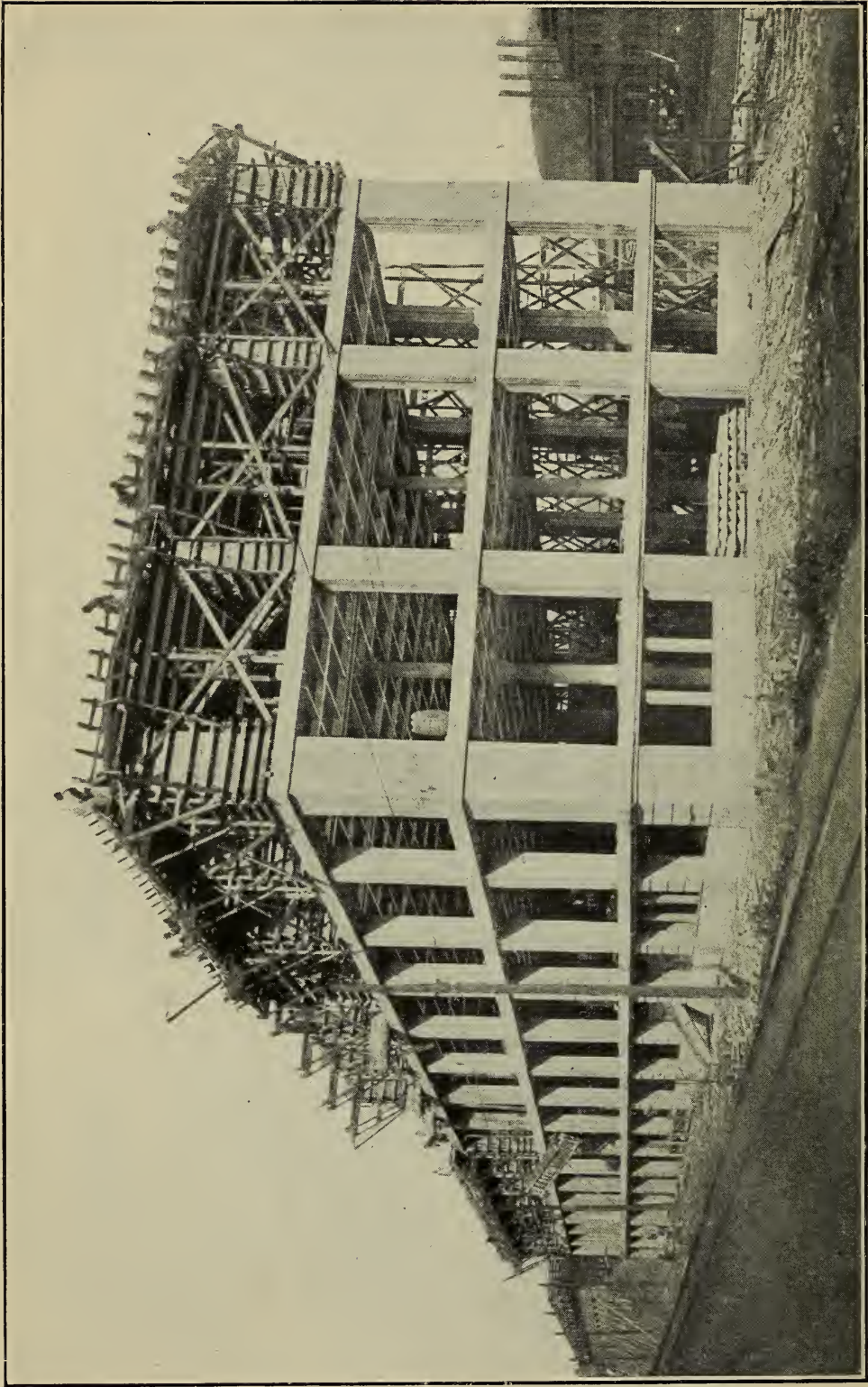
cracks in the concrete is the only effect noticeable, the strength of the material being unimpaired.

The proof which is the most convincing was that afforded by the recent Baltimore fire. In that great conflagration, every known type of construction was subjected to the flames. After the fire, engineers came from all over the country to observe what type of construction had best withstood the flames. The opinion of these experts was strikingly unanimous and decisive to the effect that concrete had stood up better than the steel frames with terra-cotta protection and, of course, better than brick and stone. In fact the two buildings in the district constructed of concrete (the United States Fidelity & Guaranty Building and the International Trust Company Building) stand like monuments to the material of which they are constructed while all around them lie shapeless heaps of broken brick, stone, and hollow tile, as well as columns and beams of structural steel distorted into fanciful shapes by the action of the fire.

**Professor Norton's
testimony regarding
the Baltimore fire**

From the great mass of expert opinion we will quote only the comments of Prof. Norton of the Massachusetts Institute of Technology as reported in the *Boston Transcript*:

“Stone, whether granite, marble, sandstone or limestone fared badly. Where floor arches and steel coverings were of concrete they stood the test much better than terra cotta. This was due probably to the fact that concrete and steel expand at the same rate while terra cotta expands $2\frac{1}{2}$ times as fast as steel and so the partitions or floor arches buckle or break. In general, the unfitness of terra cotta for beam and post covering and floor construction in comparison with concrete was demonstrated.”



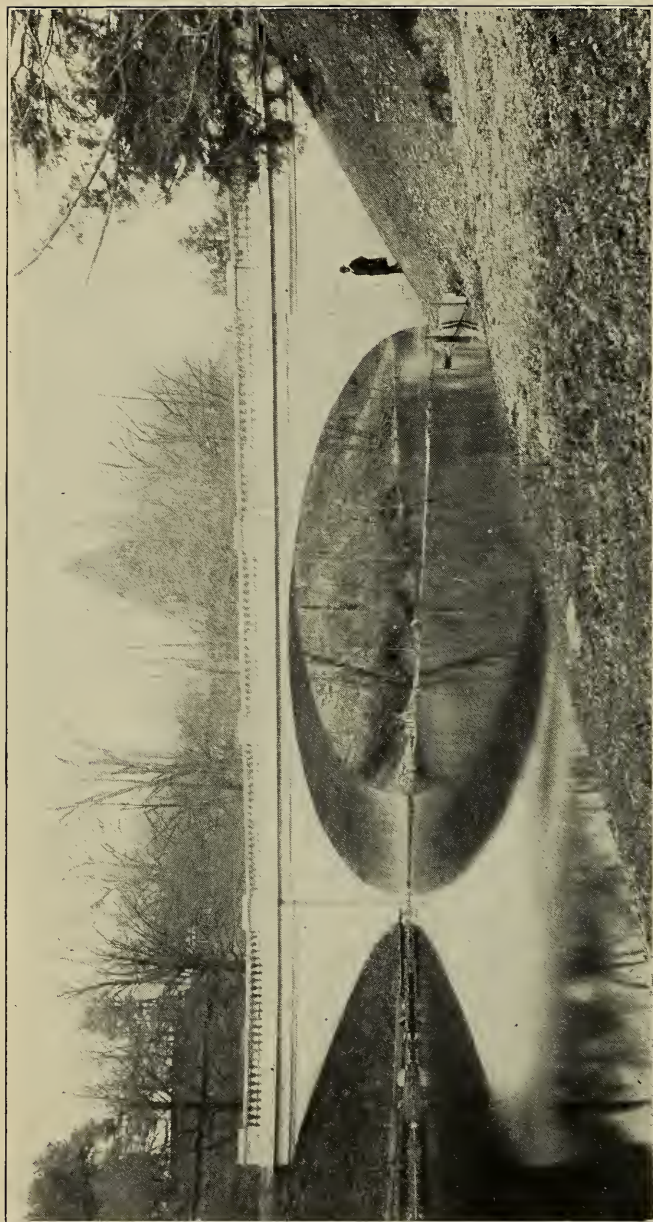
FACTORY BUILDING CONSTRUCTED ENTIRELY OF CONCRETE RE-ENFORCED WITH TWISTED STEEL RODS.

**Concrete protects
steel from corrosion**

It should be noted here that in re-enforced concrete construction the steel is completely imbedded in the concrete which absolutely protects it from fire as indeed it does from rust and all other corrosive action. It has been demonstrated in several instances that cast-iron piping which had been covered with a coat of liquid neat cement and buried underground for from ten to fifteen years, showed no signs of rust or other external deterioration. A lining of "rich" concrete has been found to be the only material which will withstand the corrosive action of the acids in the large storage tanks or vats in pulp mills.

**The strength of well-
engineered concrete
structures widely re-
cognized**

As regards the strength of concrete it must be remembered that it is in this connection that the engineer's advice is indispensable. Compression and tensile strains and the adhesion between steel and concrete must be kept within certain limits and provision must be made for wind-pressure and strains of all sorts to which the structure or any part thereof may be subjected. That concrete is at least as strong as stone is evident to anyone who has observed, in traveling over the railroads, the extent to which concrete is being used as a substitute for stone. Many railroads, among which we may mention the Pennsylvania, the Lake Shore, the Rock Island and the Lackawanna are using it for bridges, abutments, culverts, and in other places where it bears the entire burden of the tracks and the traffic passing over them. An example is the bridge of re-enforced concrete erected by the Illinois Central over the Big Muddy River. The bridge has three elliptical arches each of 140 feet clear span. It was erected at less cost



BRIDGE OF RE-ENFORCED CONCRETE ON THE ESTATE OF FREDERICK W. VANDERBILT, HYDE-PARK-ON-HUDSON, N. Y.

than a bridge of structural steel, it is more enduring and is decidedly more pleasing to the eye. A typical bridge of concrete alone, built on the straight masonry principle, is that of the Pennsylvania Railroad over the Susquehanna River, near Harrisburg, Pa. This structure is faced with a thin veneer of natural stone, which is not, however, an essential part of the structure.

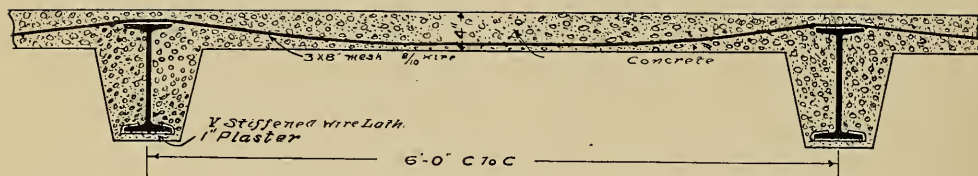
**The United States
Government employs
the material extensively**

The United States Government is using concrete in enormous quantities for all sorts of purposes. In the reconstruction of the fortifications around New York Harbor during the last few years, concrete has been used to the practical exclusion of all other materials. In other words, the thirteen-inch guns which guard the City of Steel-frame Skyscrapers are mounted on concrete foundations and are protected from hostile projectiles by the same material.

A sixteen-story concrete structure

But one more citation to demonstrate that the strength and durability of the material are officially recognized. There has just been finished in Cincinnati, Ohio, a sixteen-story office building made entirely of re-enforced concrete. The plans for this building were approved by the city authorities only after a great number of tests had been made which proved beyond the possibility of doubt that the building would be absolutely safe. Concrete enthusiasts predict that this building will be standing long after the steel skeleton structures in the neighborhood have disintegrated. The deterioration of steel when protected by nothing more than terra cotta slabs, noted in a number of cases, tends to lend strength to this view.

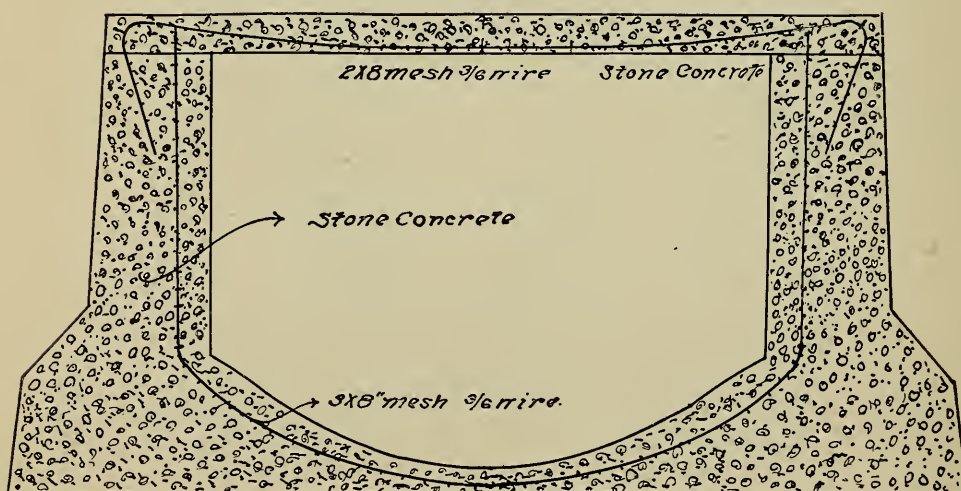
In fact, superior durability is one of the best-



Floor construction with I-beams.



Floor construction, with ceiling clipped to I-beams.



Method of re-enforcing water-mains, sewers, etc.

EXAMPLES OF RE-ENFORCEMENT WITH ELECTRICALLY WELDED WIRE FABRIC.

substantiated claims for concrete buildings. It has long been recognized that *concrete becomes stronger with age and the same is not true of any other material*. Engineers are divided in their estimates as to how long a steel-frame structure will endure.

Concrete is comparatively cheap

It might be expected that a material with so many desirable qualities would be more expensive than the materials which it is displacing. The contrary is the case. Concrete is cheaper than stone, or steel frame and terra cotta. It can be manipulated by unskilled labor to a greater extent than any other material and thus the troubles and delays due to the arbitrary actions of the unions are minimized. There are many localities in the country where no stone suitable for building purposes exists but where there is much stone admirably adapted for being crushed and used for concrete. In short, the raw materials for concrete can be laid down at almost any point in the country cheaper than any other material and the costs of putting it in place are less.

Investigation of the merits of concrete recommended

To sum up—the strength and durability of concrete, the ease with which it may be re-enforced with steel to form a combination of universal applicability, its fire-resisting and time-defying qualities and its low first cost, stamp it as the great material of the future. He who contemplates building and does so without at least examining into the merits of concrete is indeed blind to the March of Improvement.

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